

# THE EFFECTS OF STEPPED-UP MEASURES FOR SLOWING DOWN THE SPEED IN THE ETC LANE

**Akira MITSUISHI , Hiroshi OGAWA, Masatoshi YOKOTA**

*East Nippon Expressway Company Limited*

*3-3-2 Kasumigaseki, Chiyoda-ku, Tokyo 100-8979 Japan*

*a.mitsuishi.aa@e-nexco.co.jp*

## 1. ABSTRACT

For the purpose of ensuring safety for customers passing through ETC lanes, the East Nippon Expressway Company Limited (NEXCO East) has implemented stepped-up measures for slowing down the speed in ETC lanes throughout the company. According to the measures, the timing at which the toll bars open are delayed. This paper presents the results of the trial conducted ahead of the company-wide implementation of the measures. As a result, the speed has reduced drastically as well as the contacting rates with ETC toll bars. Further, in order to prevent the overall traffic flow from slowing down caused by the measures, NEXCO East conducted a trial in which customers such as drivers were visually notified of the timing at which the toll bars opened, and the effects of the trial are also introduced in this paper.

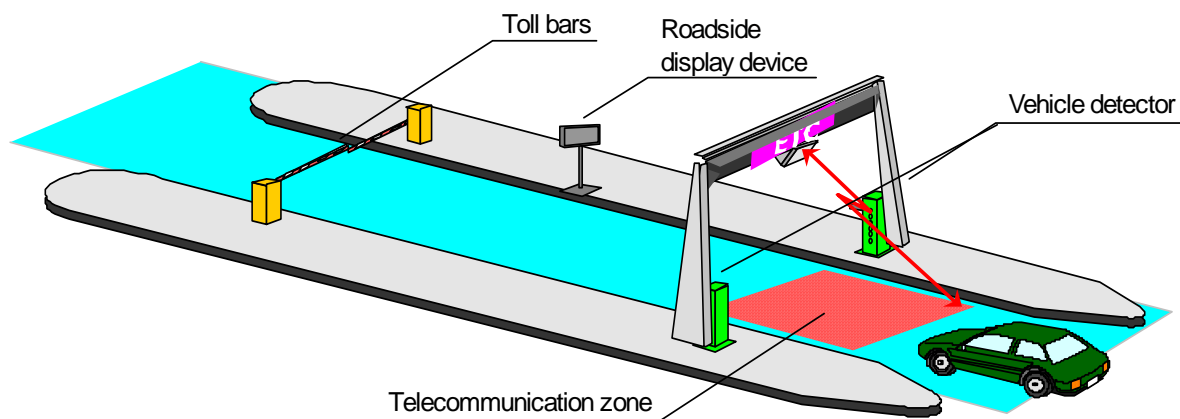


Figure 1. Overview of ETC lane

## 2. OVERVIEW OF THE ETC SYSTEM IN JAPAN

Since the full-swing introduction of ETC in Japan in 2001, ETC became widespread smoothly. As of the end of February 2009, some 77.1% of the vehicles on the nation's expressways use ETC. To collect expressway fees without fail with the use of the existing toll gates, toll bars are installed in the Japanese ETC lanes. However, since the toll bars remain closed without proper installation of the ETC card, a vehicle could collide with the toll bars or another vehicle that came to a stop in the ETC lane. Thus, vehicles need to slow down to 20 kilometres per hour or less in the ETC lane so that it can stop safely at any time. However, the speed in the ETC lane is relatively high, and the trouble caused in the lane still exists.

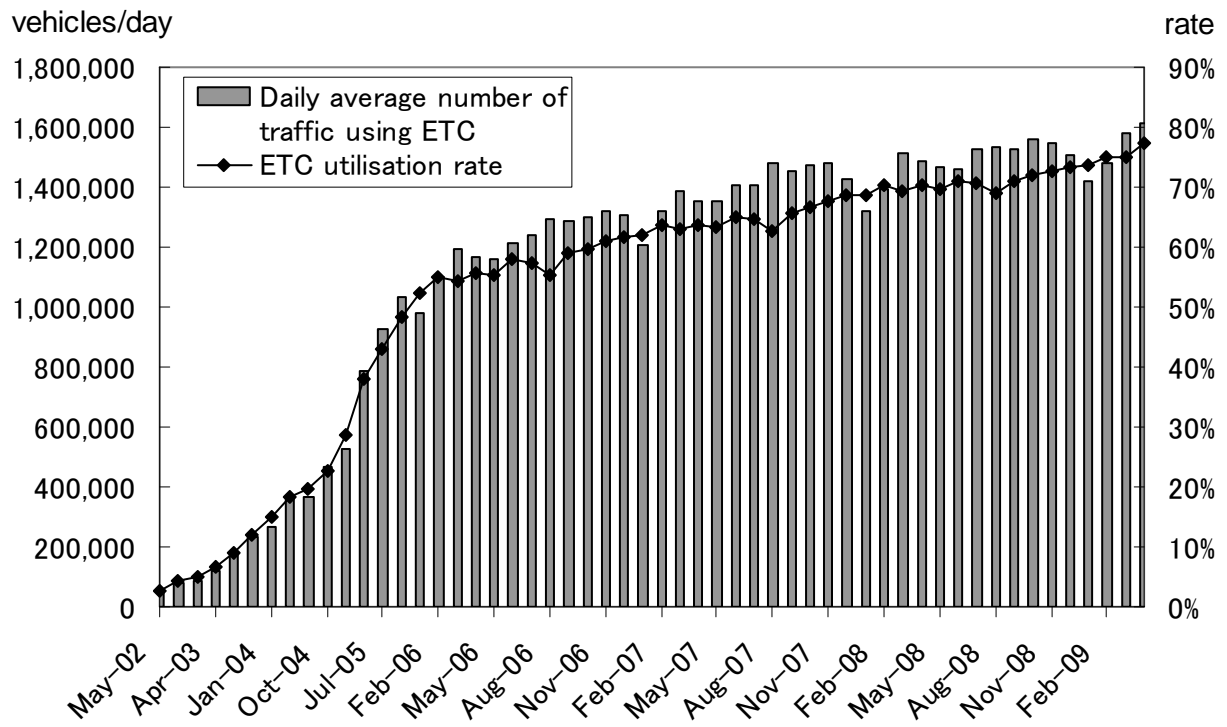


Figure 2. Transition of ETC utilisation rate

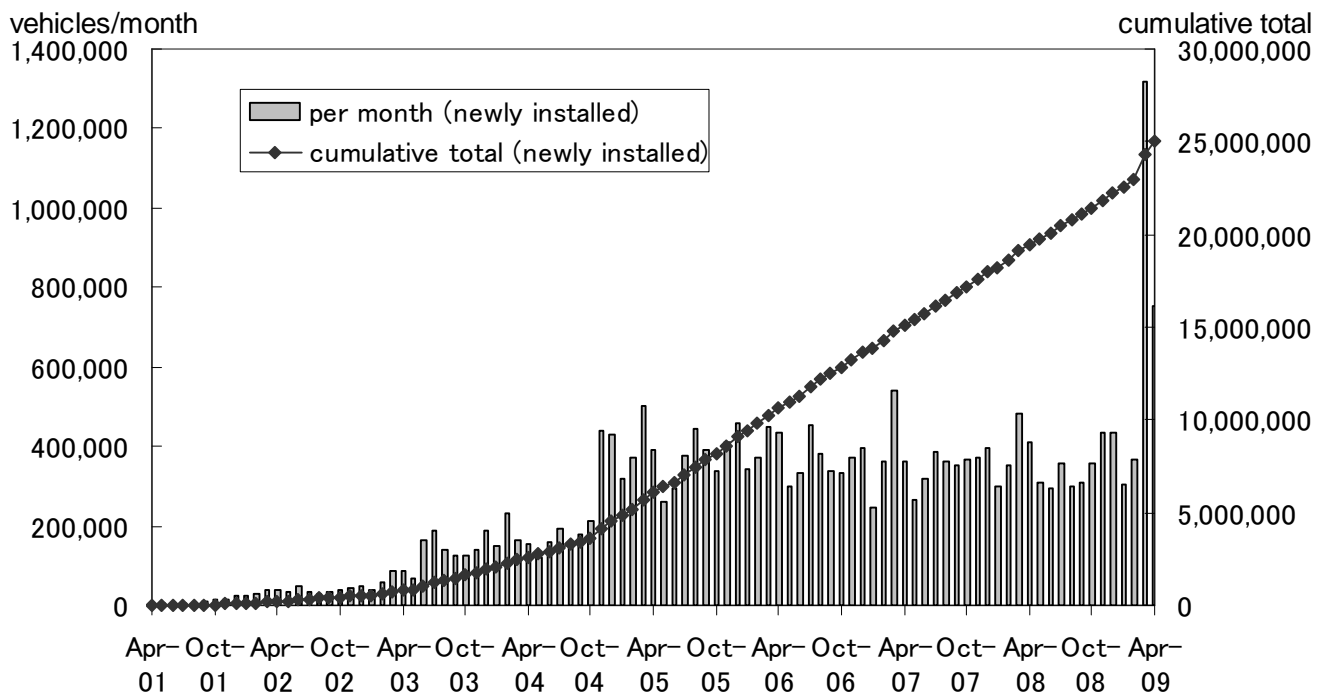


Figure 3. Transition of the number of vehicles with ETC devices

### 3. TROUBLE IN THE ETC LANE

#### 3.1. Collision in the ETC lane (with objects/vehicles)

In the NEXCO East area, no fatal accidents have so far occurred in the ETC lanes. However, there seems to be no end to accidents that involve collision with toll bars or stopped traffic.

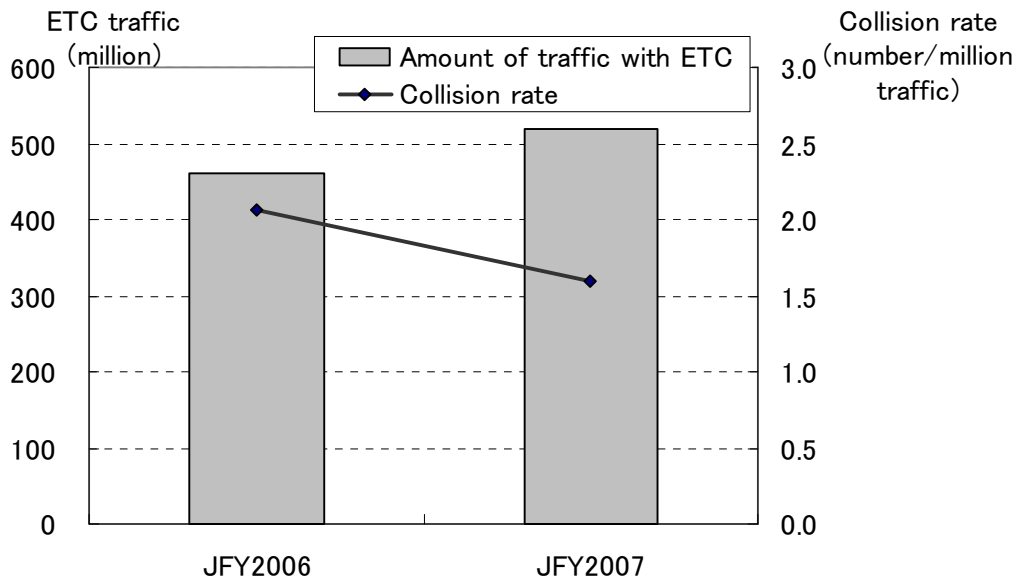


Figure 4. Collision accidents in the ETC lane  
(According to NEXCO East)

#### 3.2. Occurrence of the ETC system stop

In 2008, the ETC system stopped and the toll bars did not open for one out of approximately every 580 vehicles. Investigation of the causes showed that over 60% of the accidents resulted from ETC-card-related problems (no insertion of the card, improper card insertion, expired card, and the like) and over 30% resulted from vehicles without an ETC device entering into the ETC lane by mistake.

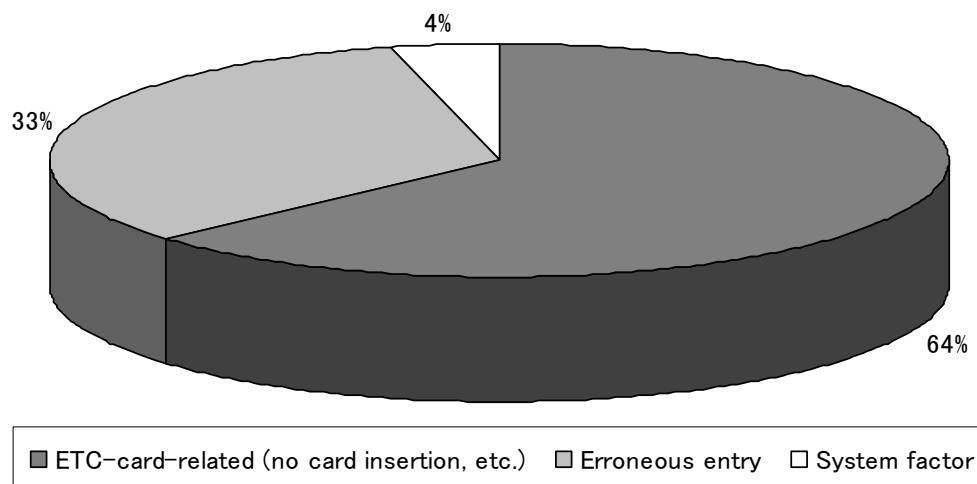


Figure 5. Causes of ETC system stop  
(According to NEXCO East in JFY2007)

### 3.3. The speed in the ETC lane (focused on collision accidents)

Investigation of the collision accidents in the ETC lane revealed that over 90% of the drivers entered the ETC lane at a speed of over 20 kilometres per hour. Thus, it is assumable that the speed makes it difficult for the drivers to stop safely.

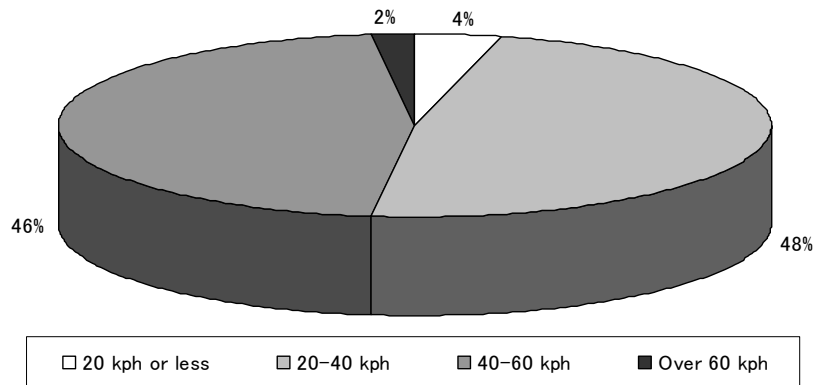


Figure 6. Speed distribution in the ETC lane when collision accident occurred (According to NEXCO East in JFY2007)

### 3.4. The mechanism of the occurrence of collision accidents

Next, the causes of collision accidents will be reviewed. While collision accidents will not occur without objects to collide with, even when such objects are present, accidents can be avoided by avoiding contact with the objects. However, it is extremely difficult to completely eliminate these objects, which can be incidentally brought about by human-made errors, such as improper insertion or no insertion of the ETC card into the ETC device and erroneous entry of non-ETC vehicles into the ETC lane. Meanwhile, it is possible to avoid contact with the objects through drivers' habitual compliance with safety speed when passing through the ETC lane. NEXCO East has so far taken measures in terms of these two points, and the purpose of the measures is to avoid contact with objects to collide with.

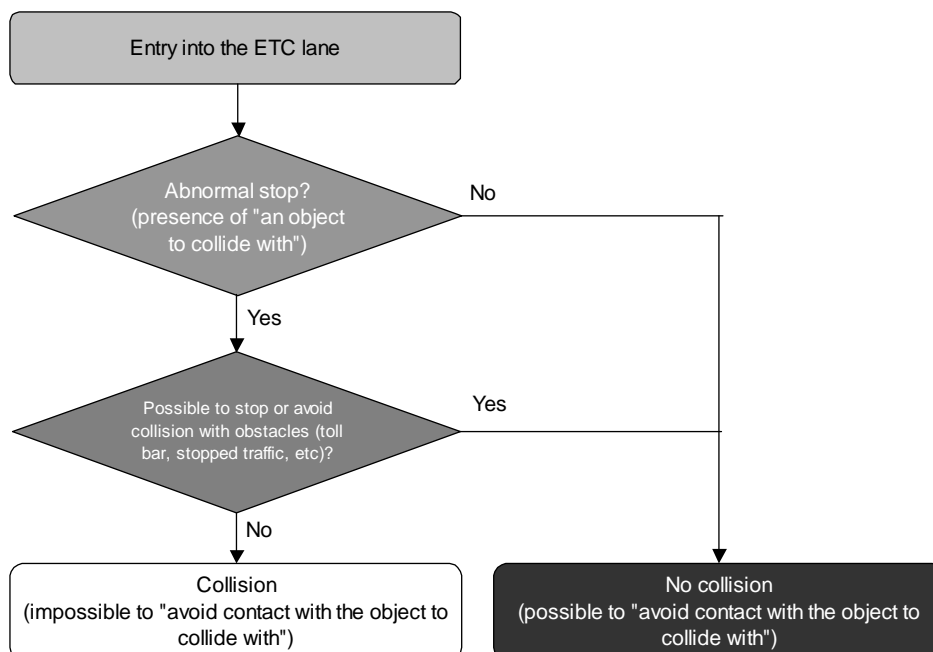


Figure 7. Mechanism of the occurrence of collision

#### **4. CONVENTIONAL MEASURES FOR SLOWING DOWN THE SPEED IN THE ETC LANE**

In the past, the company carried out several measures (including trials) for slowing down the speed in the ETC lane. While the measures were aimed at drawing the attention of drivers aurally, tactually and visually, none of the measures provided sufficient or continued effect.

#### **5. STEPPED-UP MEASURES FOR SLOWING DOWN THE SPEED IN THE ETC LANE**

##### **5.1. Concept of the measures introduced**

As described in the above, based on the conventional measures for slowing down the speed in the ETC lane, “warning” is given to drivers. Therefore, reducing the speed is dependent on the drivers’ decision (and decency) who have received the warning. Consequently, sufficient effect has not been obtained so far.

Thus, new measures were explored from a different perspective; that is, measures that make it physically impossible to increase the speed were explored.

##### **5.1.1. Humps and corrugated pavement**

Humps and corrugated pavement are installed on some of the streets to slow down the vehicle speed. If vehicles pass through these Humps or corrugated pavement at over a given speed, the vehicles may come into contact with the road surface or the steering wheel may be uncontrollable, making it difficult to drive. Because of these effects, issues including impact of the vibration on freight and safety for two-wheel vehicles need to be sufficiently considered. Since these measures have never been adopted for expressways, it is impossible to introduce them immediately. Therefore, these measures were excluded from the stepped-up measures this time.

##### **5.1.2. Delay in the timing at which the toll bars open**

In the autumn of 2007, NEXCO Central started the trial and delayed the timing at which the toll bars open in the ETC lane, and it is found that the trial has been effective. Since NEXCO East’s expressways are seamlessly connected to NEXCO Central’s expressways, it was decided that the introduction of the measures should be explored.

\*Japan Highway Public Corporation was privatised and divided into three NEXCOs, i.e. NEXCO East, NEXCO Central and NEXCO West in October, 2005.

##### **5.2. Principle of the measures**

The principle of the measures is to delay the timing at which the toll bars open in order to slow down the speed of vehicles passing through the ETC lane. The measures enable reduction in speed physically and visually.

When a vehicle passes through the vehicle detector (see Figure. 1), a signal that activates the toll bars is generated. In the conventional system, there was little time lag between the detection by the detector and generation of the toll bar activation signal. According to the stepped-up measures, by changing the timing at which

the toll bars open, the time lag was increased by approximately 0.5 to 1 second, compared with before. The time lag differs depending on the toll gate. (This is because the distance between the vehicle detector and the toll bars varies depending on the toll gate. For reference's sake, the design scheme of NEXCO East defines a minimum of 11.9 metres for the distance.).

### 5.3. Concept of the trial

After NEXCO Central, NEXCO West also initiated a trial implementation of the measures in 2007 and subsequently it has been expanding the measures throughout the company. NEXCO East examined the effectiveness of the measures first, and launched the trial in September 2008. This is to verify whether or not various factors (the type of interchange and the amount of traffic, for example), which are different from NEXCO Central's and West's trial items, could be risk factors. Particularly, since NEXCO East has many mainline toll gates (namely, places where the amount of traffic is relatively heavy and it is difficult to slow down the speed linearly), 7 places were selected as the trial sites after reviewing all the conditions.

Table 1. Trial locations and data concerning the stepped-up measures for slowing down the speed

Prefecture	IC	Branch	IC type	Traffic (thousand/day)	ETC utilisation rate (%)	Average speed (kph)
Hokkaido	Shinkawa (Sasson Expwy)	Hokkaido	Plane and direct	11	59	29
Miyagi	Iwanuma (Sendai tobu)	Tohoku	Plane and T-intersection (entrance) Y-intersection (exit)	4	56	34 (exit)
Tochigi	Shikanuma (Tohoku Expwy)	Kanto	Trumpet-shaped	14	73	36 (entrance)
Nagano	Kosyoku (Nagano Expwy)	Kanto	Trumpet-shaped	10	77	33 (entrance)
Nagano	Omi (Nagano Expwy)	Kanto	Trumpet-shaped	2	77	35 (entrance)
Chiba	Kisarazu-Kaneda (Aqualine)	Kanto	Mainline toll gate	13	86	43 (exit)
Niigata	Niigata West No.1 (Hokuriku Expwy)	Niigata	Mainline toll gate	19	73	37 (exit)

### 5.4. Public relations activities concerning the trial

In order to lower the speed of vehicles passing through the ETC lane and reduce trouble such as collision with the toll bars through the implementation of the measures, it is necessary that customers such as drivers fully understand the details and the purpose of the measures. Therefore, PR activities were carried out. The locations where the PR activities should be conducted were discussed to include various locations before driving, on the expressway, and immediately before the ETC lane. For drivers before driving, the information was aired on the radio commercial. For drivers on the expressway, the posters were put up and leaflets were distributed in rest areas, and the information was provided on variable message signs and through the expressway radio. Sign boards and LED display devices were installed, and security officers alerted drivers immediately before the ETC lane (LED display devices were installed only for the first 2 to 3 months at trial sites where the amount of traffic was relatively

heavy, and security staff alerted drivers only for the first 1 to 2 weeks at each trial site.).



Photo 1. Information on variable message sign



Photo 2. Information on LED display device



Photo 3. Security staff alerting drivers

## 5.5. Trial results

At the Hokuriku Expressway Niigata West toll gate, which is in accord with the mainline toll gate in terms of type and traffic, the trial started in 25 September 2008. It was found that the share of vehicles number passing at a relatively high speed of 40 kilometres per hour or higher has been reduced to 1/4, and the rate of number of vehicles colliding with the toll bars has been reduced to 1/2 or less. In addition, four months after the initiation of the trial, the measures have still been effective. It is thought that these successes are the result of the sufficient promotion of the measures and drivers' good understanding of the purpose of the measures. Moreover, there have been no accidents or complaints reported.

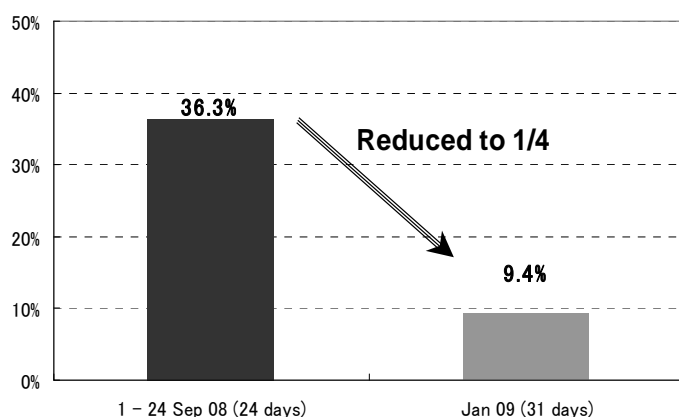


Figure 8. Transition of the share of vehicles number at 40 kph or higher at Niigata West entrance toll gate

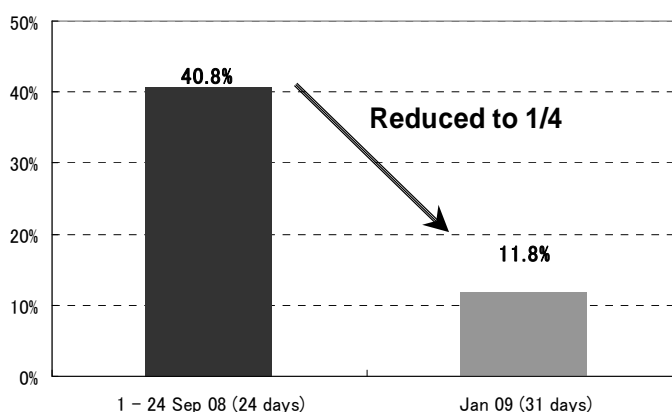


Figure 9. Transition of the share of vehicles number at 40 kph or higher at Niigata West exit toll gate

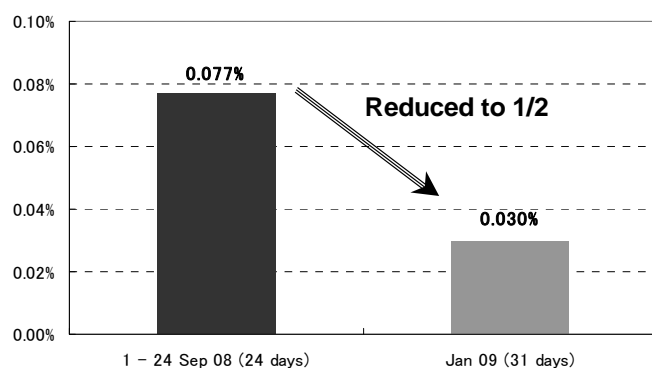


Figure 10. Transition of the rate of number of vehicles colliding to the toll bars at Niigata West entrance toll gate

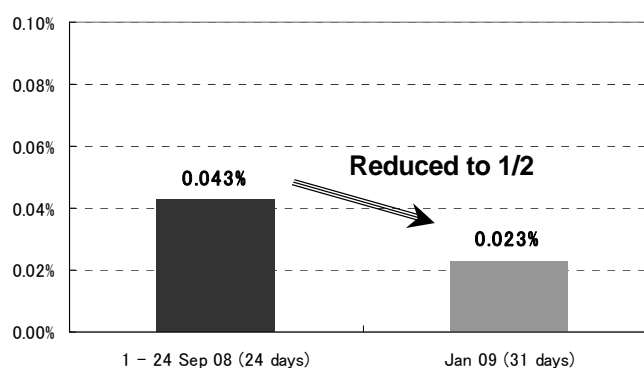


Figure 11. Transition of the rate of number of vehicles colliding to the toll bars at Niigata West exit toll gate

## 5.6. Future issues (for company-wide operation)

From these trial results, the effectiveness of the measures (not only reduction of the speed, but also reduction of the number of vehicles colliding with the toll bars) was confirmed. In addition, since no problems, such as receiving complaints, have been confirmed, NEXCO East decided to expand the measures throughout the company.

It is thought that the success of the trial is due to the sufficient promotion of the measures. Thus, for the company-wide operation, the measures need to be promoted through even more effective PR activities than those of the trial, to gain customers' (drivers') understanding of the measures.

## 6. THE MEASURE FOR RESTRAINING THE SPEED DISPERSION IN THE ETC LANE (DISPLAYING THE TIMING AT WHICH THE TOLL BARS OPEN)

### 6.1. Background and purpose

The data from the trial previously conducted by NEXCO Central showed that the measures caused the overall speed distribution in the ETC lane to shift to a lower speed range. Namely, it was found that not only drivers who normally passed at a relatively high speed, but also drivers who normally passed at a relatively low speed are passing at an even lower speed than before. For this reason, the following issues are assumed.

(1) Even drivers who normally passed through the ETC lane at a specified speed are influenced by the traffic flow or the like and put on the brake, which may cause stress to the drivers.

(2) In order to achieve a smooth flow of traffic, the speed distribution needs be as small as possible. According to the trial results by NEXCO Central, there is a possibility that the measures widened the speed distribution.

Therefore, in order to ensure smaller speed distribution and smoother traffic flow, as a trial, drivers were visually notified of the timing at which the toll bars opened.

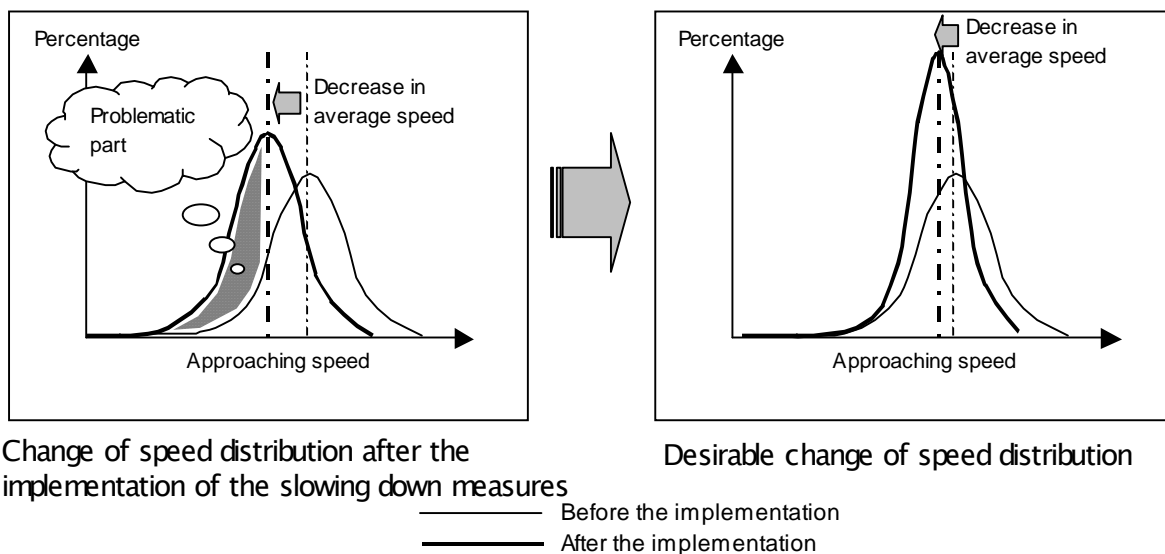


Figure 12. Change of speed distribution



## 6.2. The principle of the measures

In view of the existing equipment and the like, a general-purpose LED display device was installed near the toll bars. The timing at which the toll bars opened was displayed by providing information in a countdown manner.

The vehicle detector (Fig. 1) located most upstream of the ETC lane was used as a trigger to activate the LED display device, as in the stepped-up measures for slowing down the speed. Therefore, since the distance between the vehicle detector and the LED display device was not sufficiently long (merely more than 10 metres), multi-step change of information displayed on the LED display device was made within a short time.



Photo 4. Installation of LED display device

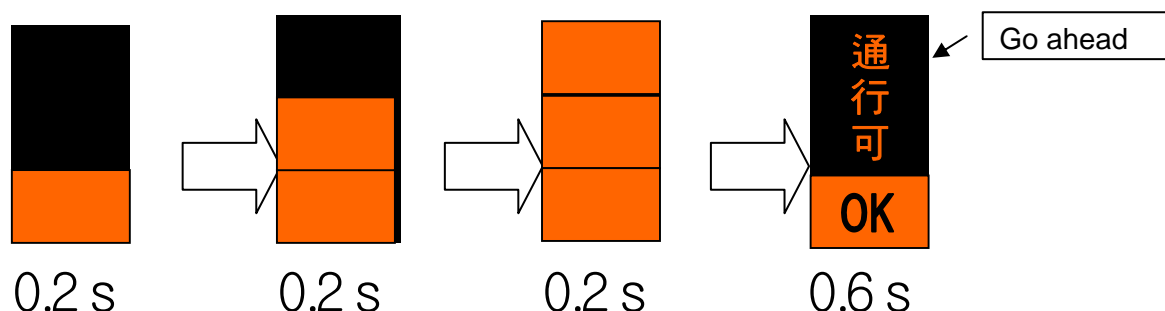


Figure 13. Information displayed and switching time of LED display device ("s" for second)

## 6.3. Preparation for the trial

In order to evaluate the effectiveness of the trial using the LED display device in the reduction of the speed dispersion, whether the presence of the LED display device affects the speed dispersion needs to be examined. If only some of the multiple ETC lanes, which are arranged next to each other in the same direction and are located in the same toll gate, have the LED display device, there is a possibility that drivers may be confused about which lane to enter. Therefore, by taking into account the direction at one toll gate, it was decided that the LED display devices should be installed at either the entrance or the exit, and the trial was then conducted.

When selecting the toll gate to be provided with LED display devices, one having approximately the same traffic amount and speed distribution at its entrance and exit was sought. In view of this, the Hokuriku Expressway Niigata West toll gate was selected as the trial site, which was one of the trial sites at which the measures for slowing down the speed were implemented (unlike a typical type of IC with curvy ramps, the Niigata West toll gate is located at a place that linearly and directly connects to a national highway from the expressway mainline, and the gate is similar to a mainline toll gate.).

As to whether the entrance or the exit should be chosen, several factors were examined. Since the hourly

traffic volume was determined as a main factor, the trial was implemented at the entrance (rapid increase in hourly traffic volume might increase the risk of rear-end collision.).

## 6.4. Results of the trial

### 6.4.1 Distribution of approaching speed into the ETC lane

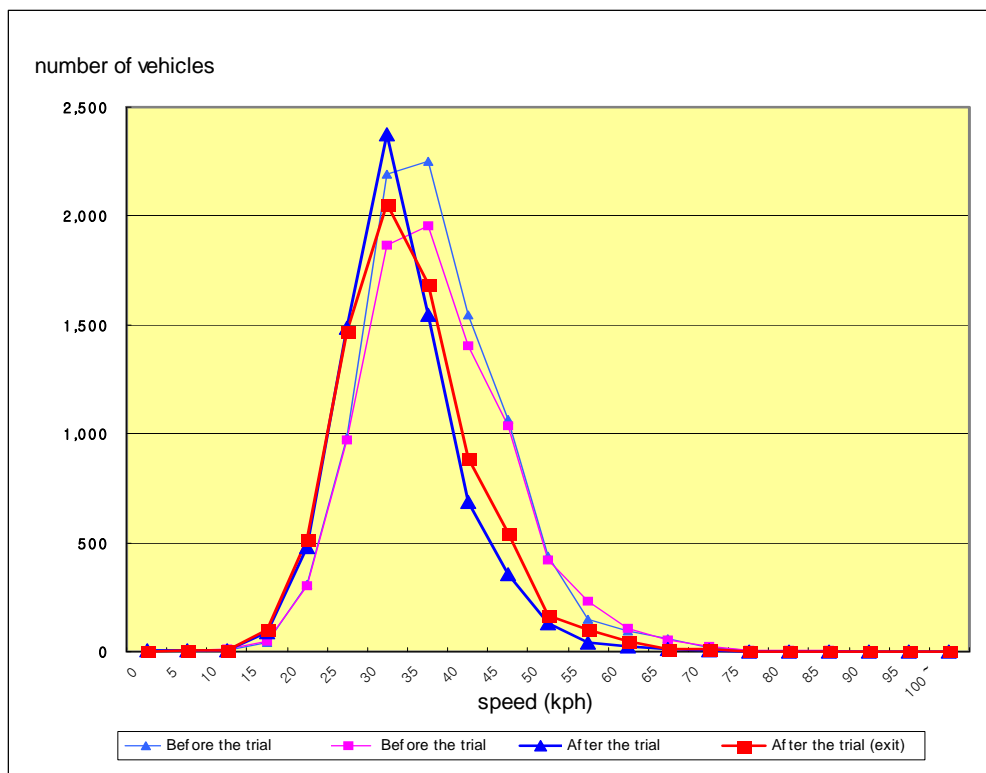


Figure 14. Speed distribution in the ETC lane at Niigata West toll gate (before and after the implementation of the trial for slowing down the speed)

The distribution of approaching speed into the ETC lane shows no significant differences between the exit at which the trial for slowing down the speed was implemented and the entrance at which the trial was not implemented. However, since a decrease in the high speed range was seen at the exit, it can be assumed that the result is attributable to the effects of the display of the timing at which the toll bars open.

### 6.4.2 Results of the questionnaire survey

According to the results of the questionnaire survey conducted at a rest area located adjacent to the Niigata West toll gate, approximately 70% of the drivers answered that they noticed the display of the timing and found it useful. There were other drivers, stating “It was not easy to find the LED display,” “The display time was short,” and “A blinking or multiple-colour LED display could be better.” Since the LED display device had to be installed between existing equipment, the device could not be installed at the best place for the customers.

However, the trial was conducted smoothly without any accidents or complaints.

## **6.5. Future issues**

Further effective methods using the display of the timing are being explored. As to the installation position of the LED display device, visibility from customers needs to be the first priority. Other issues include an extension of the display time of the LED display device, change of the display design, change of the number of display patterns (the number of display changes), and use of colours.

## **7. CONCLUSION**

NEXCO East implemented the company-wide stepped-up measures for slowing down the speed on 16 March 2009 and had finished by the end of this April, after the examination of the effectiveness of the measures, selection of the trial sites, implementation of the trails, and assessment of the trial results. There have been no accidents so far. The measures are straightforward but found to be very effective, and thus, the company will continuously focus on the stability of the effects and the operation of the measures.

In addition, as to the effects of the display of the timing, the presence of the display device has so far indicated no significant difference in speed distribution. Therefore, the company needs to make improvements in providing customers with information, including display methods and contents to be displayed.

In closing, the deepest appreciation goes to NEXCO Central for suggesting the introduction of the measures for slowing down the speed to NEXCO East.

## **REFERENCES**

1. ETC Handbook 2008 edition, ORSE: Organization for Road System Enhancement